

## CLAIMS

1. A method for fabricating a spring structure including a spring finger having a first end attached to a substrate, a second end including a tip, and a central section extending between the first and second ends such that the tip is located a selected target distance from the substrate, the method comprising:

forming the spring finger on the substrate such that the first end, the second end and the central section are attached to the substrate;

releasing the central section and second end of the spring finger such that the first end remains attached to the substrate and the central section and second end are detached from the substrate; and

annealing the spring finger such that the central section achieves a selected curvature and the tip is positioned at the selected target distance from the substrate, wherein said annealing includes utilizing at least one of a pre-release annealing process, which is performed before releasing the central section and second end, and a post-release annealing process, which is performed after releasing the central section and second end.

2. The method according to Claim 1, wherein forming the spring finger comprises sputter depositing a metal film such that the sputtered metal film includes a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

3. The method according to Claim 1, wherein forming the spring finger comprises generating a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

4. The method according to Claim 1, wherein forming the spring finger comprises generating a strain gradient that changes in a direction perpendicular to an upper surface of the substrate.

5. The method according to Claim 1, wherein said annealing is performed after said releasing, wherein the tip is positioned at a release tip distance from the substrate after said releasing, and said tip is positioned at the selected target distance from the substrate after annealing.

6. The method according to Claim 5, wherein the spring finger is subjected to a maximum production temperature during forming and releasing, and wherein said annealing comprises heating the spring finger to a post-release annealing temperature that is greater than the maximum production temperature.

7. The method according to Claim 6, further comprising:

comparing the release tip height with the selected target distance after said releasing; and

determining the post-release annealing temperature based on a difference between the release tip height and the selected target distance.

8. The method according to Claim 6, further comprising:

comparing the release tip height with the selected target distance after said releasing; and

determining the post-release annealing time at a predetermined annealing temperature based on a difference between the release tip height and the selected target distance.

9. The method according to Claim 1, wherein said annealing is performed before said releasing.

10. The method according to Claim 9, wherein the spring finger is subjected to a maximum formation temperature during forming, and wherein annealing comprises heating the spring finger to a pre-release annealing temperature that is greater than the maximum formation temperature.

11. The method according to Claim 10, further comprising:

releasing a benchmark spring structure and measuring a benchmark tip height of the benchmark spring structure;

comparing the benchmark tip height with the selected target distance; and

determining the pre-release annealing temperature based on a difference between the benchmark tip height and the selected target distance.

12. The method according to Claim 9, wherein annealing further comprises heating the spring finger after

said releasing to a second annealing temperature that is greater than the pre-release annealing temperature.

13. The method according to Claim 9, wherein annealing further comprises heating the spring finger after said releasing to a post-release annealing temperature.

14. The method according to Claim 13, wherein the post-release annealing temperature is greater than or equal to the pre-release annealing temperature.

15. The method according to Claim 1, further comprising determining an expected maximum temperature to which the spring structure will be subjected, and wherein said annealing comprises heating to an annealing temperature that is greater than or equal to the expected maximum temperature.

16. The method according to Claim 1, wherein said annealing comprises uniformly heating the substrate using one of a hot plate and an oven.

17. The method according to Claim 1, wherein said annealing comprises directing a laser beam onto the spring finger.

18. The method according to Claim 1, wherein said annealing comprises passing a current through the spring finger.

19. The method according to Claim 1, wherein said annealing comprises said annealing a first section of the

spring finger at a first, relatively high temperature, and annealing a second section of the spring finger at a second, relatively low temperature, whereby a greater curvature is generated in the first region than in the second region.

20. The method according to Claim 19, wherein said annealing comprises heating the first section to the first temperature using a laser beam.

21. The method according to Claim 19, wherein said annealing comprises forming one of a heat absorbing material and a heat reflecting material on the spring finger.

22. A method for fabricating a spring structure including a spring finger having a first end attached to a substrate, a second end including a tip, and a curved central section extending between the first and second ends such that the tip is located a selected target distance from the substrate, the method comprising:

forming the spring finger on the substrate such that the first end, the second end and the central section are attached to the substrate;

annealing the spring finger at a pre-release annealing temperature while the first end, the second end, and the central section are attached to the substrate; and

releasing the central section and second end of the annealed spring finger such that the first end remains attached to the substrate and the central section and second end are detached from the substrate.

23. The method according to Claim 22, wherein forming the spring finger comprises sputter generating a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

24. The method according to Claim 22, wherein forming the spring finger comprises generating a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

25. The method according to Claim 22, wherein forming the spring finger comprises depositing a metal film over the substrate such that the metal film includes a strain gradient that changes in a direction perpendicular to an upper surface of the substrate.

26. The method according to Claim 22, wherein the spring finger is subjected to a maximum formation temperature during forming, wherein annealing comprises heating the spring finger to the pre-release annealing temperature, and wherein the pre-release annealing temperature is greater than the maximum formation temperature.

27. The method according to Claim 26, further comprising:

releasing a benchmark spring structure and measuring a benchmark tip height of the benchmark spring structure;

comparing the benchmark tip height with the selected target distance; and

determining the pre-release annealing temperature based on a difference between the benchmark tip height and the selected target distance.

28. The method according to Claim 26, further comprising:

releasing a benchmark spring structure and measuring a benchmark tip height of the benchmark spring structure;

comparing the benchmark tip height with the selected target distance; and

determining an annealing time period at the pre-release annealing time based on a difference between the benchmark tip height and the selected target distance.

29. The method according to Claim 22, further comprises heating the spring finger after said releasing to a post-release annealing temperature that is greater than the pre-release annealing temperature.

30. The method according to Claim 22, further comprising determining an expected maximum temperature to which the spring structure will be subjected, wherein said pre-release annealing temperature is greater than or equal to the expected maximum temperature.

31. The method according to Claim 22, wherein said annealing comprises uniformly heating the substrate using one of a hot plate and an oven.

32. The method according to Claim 22, wherein said annealing comprises directing a laser beam onto the spring finger.

33. A method for fabricating a plurality of spring structures on a substrate, each spring structure including a spring finger having a first end attached to the substrate, a second end including a tip, and a curved central section extending between the first and second ends such that the tip is located a selected target distance from the substrate, the method comprising:

forming the plurality of spring structures on the substrate such that the first end, the second end and the central section of each spring finger are attached to the substrate;

releasing the central section and second end of a first spring structure such that the first end remains attached to the substrate, and the central section and second end are detached from the substrate such that the tip of the first spring structure is located at a benchmark distance from the substrate;

comparing the benchmark distance and the selected target distance;

determining a pre-release annealing temperature based on a difference between the benchmark distance and the selected target distance;

annealing a second spring structure at the determined pre-release annealing temperature; and

releasing the central section and second end of the annealed second spring structure such that the first end remains attached to the substrate, and the central section bends away from the substrate, wherein the tip of the second spring structure is positioned at the predetermined distance from the substrate.



34. The method according to Claim 33, wherein forming the spring finger of each of the plurality of spring structures comprises sputter depositing a metal film such that the sputtered metal film includes a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

35. The method according to Claim 33, wherein forming the spring finger of each of the plurality of spring structures comprises plating a metal film over the substrate such that the plated metal film includes a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

36. The method according to Claim 33, wherein forming the spring finger of each of the plurality of spring structures comprises depositing a metal film over the substrate such that the metal film includes a strain gradient that changes in a direction perpendicular to an upper surface of the substrate.

37. The method according to Claim 33, wherein the spring finger of each of the plurality of spring structures is subjected to a maximum formation temperature during forming, and wherein the pre-release annealing temperature is greater than the maximum formation temperature.

38. The method according to Claim 33, further comprises heating the spring finger of the second spring structure after said releasing to a post-release annealing temperature that is greater than the pre-release annealing temperature.

39. The method according to Claim 33, further comprising determining an expected maximum temperature to which the spring structure will be subjected, wherein said pre-release annealing temperature is greater than or equal to the expected maximum temperature.

40. The method according to Claim 33, wherein said annealing comprises uniformly heating the substrate using one of a hot plate and an oven.

41. The method according to Claim 33, wherein said annealing comprises directing a laser beam onto the spring finger.

42. The method according to Claim 33, wherein said annealing comprises passing a current through the spring finger.

43. A method for fabricating a spring structure on a substrate, the spring structure including a first end attached to the substrate, a second end including a tip, and a curved central section extending between the first and second ends such that the tip is located a selected target distance from the substrate, the method comprising:

forming the spring finger on the substrate such that the first end, the second end and the central section are attached to the substrate;

releasing the central section and second end of the spring finger such that the first end remains attached to the substrate and the central section and second end are detached from the substrate;

comparing an initial tip height, which is measured between the tip of the released spring finger and the substrate, with the selected target distance;

determining a post-release annealing temperature based on a difference between the initial tip height and the selected target distance; and

annealing the released spring structure at the post-release annealing temperature such that the central section bends away from the substrate, and the tip of the spring structure is positioned at the selected target distance from the substrate.

44. The method according to Claim 43, wherein forming the spring finger comprises sputter depositing a metal film such that the sputtered metal film includes a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

45. The method according to Claim 43, wherein forming the spring finger comprises plating a metal film over the substrate such that the plated metal film includes a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

46. The method according to Claim 43, wherein forming the spring finger comprises depositing a metal film over the substrate such that the metal film includes a strain gradient that changes in a direction perpendicular to an upper surface of the substrate.

47. The method according to Claim 43, wherein the spring finger is subjected to a maximum production

temperature during forming and releasing, and wherein the post-release annealing temperature is greater than the maximum production temperature.

48. The method according to Claim 43, further comprising determining an expected maximum temperature to which the spring structure will be subjected during operation, and wherein the post-release annealing temperature is greater than or equal to the expected maximum temperature.

49. The method according to Claim 43, wherein said annealing comprises uniformly heating the substrate using one of a hot plate and an oven.

50. The method according to Claim 43, wherein said annealing comprises directing a laser beam onto the spring finger.

51. The method according to Claim 43, wherein said annealing comprises passing a current through the spring finger.

52. A method for fabricating a plurality of spring structures on a substrate, each spring structure including a spring finger first end attached to a substrate, a second end including a tip, and a curved central section extending between the first and second ends such that the tip is located a selected target distance from the substrate, the method comprising:

forming first and second spring structures on the substrate such that the first end, the second end and the

central section of the spring fingers associated with the first and second spring structures are attached to the substrate;

releasing the central section and second end of the spring fingers associated with the first and second spring structures such that the first ends of the spring fingers associated with the first and second spring structures remain attached to the substrate and the central sections and second ends of the spring fingers associated with the first and second spring structures are detached from the substrate;

comparing the selected target distance with a first initial distance measured between the tip of the first spring structure and the substrate, and with a second initial distance measured between the tip of the second spring structure and the substrate;

determining a first annealing temperature based on the first measured initial distance and a second annealing temperature based on the second measured initial distance; and

annealing the first spring structure at the first annealing temperature such that the central section of the first spring structure bends away from the substrate until the tip of the first spring structure is located at the selected target distance from the substrate, and annealing the second spring structure at the second annealing temperature such that the central section of the second spring structure bends away from the substrate until the tip of the second spring structure is located at the selected target distance from the substrate.

53. A method for mass producing a plurality of spring structures, each spring structure including a spring finger having a first end attached to an associated substrate, a second end including a tip, and a central section extending between the first and second ends such that the tip is located a target distance from the associated substrate, the method comprising:

producing a cache of unreleased spring structures including a first spring structure formed on a first substrate and a second spring structure formed on a second substrate, wherein the first end, the second end, and the central section of the spring fingers associated with each unreleased spring structure are attached to the substrate;

annealing and releasing a first spring structure from the cache of unreleased spring structures according to a first annealing schedule of the plurality of annealing schedules, whereby the tip of the first spring structure is located a first target distance from the associated substrate; and

annealing and releasing a second spring structure from the cache of unreleased spring structures according to a second annealing schedule of the plurality of annealing schedules, whereby the tip of the second spring structure is located a second target distance from the associated substrate.

54. The method according to Claim 53, wherein producing the cache comprises fabricating the unreleased first and second spring structures such that the first and second spring structures have a common stress gradient.

55. The method according to Claim 53, wherein producing the cache comprises fabricating the unreleased first and second spring structures such that the first and second spring structures have a common strain gradient.

56. The method according to Claim 53, further comprising determining the first annealing schedule and the second annealing schedule before annealing the first and second spring structures.

57. A method for fabricating a spring structure including a spring finger having a first end attached to a substrate, a second end including a tip, and a central section extending between the first and second ends such that the tip is located a selected target distance from the substrate, the method comprising:

forming the spring finger on the substrate such that the first end, the second end and the central section are attached to the substrate;

releasing the central section and second end of the spring finger such that the first end remains attached to the substrate and the central section and second end are detached from the substrate, whereby the tip is positioned at a release distance from the substrate, wherein the release distance is less than the selected target distance;

annealing the spring finger at a predetermined annealing temperature for an annealing time period such that the central section bends away from the substrate and the tip is positioned at the selected target distance,

wherein the annealing time period is calculated based on the predetermined annealing temperature and a difference

between the release distance and the selected target distance.

58. The method according to Claim 57, wherein forming the spring finger of each of the plurality of spring structures comprises plating a metal film over the substrate such that the plated metal film includes a stress gradient that changes in a direction perpendicular to an upper surface of the substrate.

59. The method according to Claim 57, wherein forming the spring finger of each of the plurality of spring structures comprises depositing a metal film over the substrate such that the metal film includes a strain gradient that changes in a direction perpendicular to an upper surface of the substrate.

60. The method according to Claim 57, wherein the spring finger is subjected to a maximum production temperature during forming and releasing, and wherein said predetermined annealing temperature is greater than the maximum production temperature.

61. A method for fabricating a plurality of spring structures on a substrate, each spring structure including a spring finger first end attached to a substrate, a second end including a tip, and a curved central section extending between the first and second ends such that the tip is located a selected target distance from the substrate, the method comprising:

forming first and second spring structures on the substrate such that the first end, the second end and the



central section of the spring fingers associated with the first and second spring structures are attached to the substrate;

releasing the central section and second end of the spring fingers associated with the first and second spring structures such that the first ends of the spring fingers associated with the first and second spring structures remain attached to the substrate and the central sections and second ends of the spring fingers associated with the first and second spring structures are detached from the substrate;

comparing the selected target distance with a first initial distance measured between the tip of the first spring structure and the substrate, and with a second initial distance measured between the tip of the second spring structure and the substrate, wherein the first initial distance is less than the second initial distance;

determining a first annealing time period based on the first measured initial distance, and a second annealing time period based on the second measured initial distance; and

annealing the first spring structure at a predetermined annealing temperature for the first annealing time period such that the central section of the first spring structure bends away from the substrate until the tip of the first spring structure is located at the selected target distance from the substrate, and annealing the second spring structure for the second annealing time period such that the central section of the second spring structure bends away from the substrate until the tip of the second spring structure is located at the selected target distance from the substrate, wherein the first

A3235 (XCP-035)

Express Mail: EV 302 354 327 US

annealing time period is greater than the second annealing time period.